

CLAIMS

1. A rubber-reinforced structure which comprises
at least one resin member comprising a resin composition,
5 and at least one rubber layer or rubber member being
directly bonded to the resin member without any adhesive,
wherein the resin member and the rubber layer or rubber
member form a tire, the rubber layer or rubber member
comprises a rubber composition vulcanized with a
10 radical-generating agent, the resin member comprises a
thermoplastic resin having at least two active atoms on
the average per molecule, and each of the atoms is selected
from the group consisting of a hydrogen atom and a sulfur
atom and has an orbital interaction energy coefficient S
15 of not less than 0.006,

wherein the orbital interaction energy
coefficient S is represented by the following formula (1):

$$S = (C_{\text{HOMO},n})^2 / |E_c - E_{\text{HOMO},n}| + (C_{\text{LUMO},n})^2 / |E_c - E_{\text{LUMO},n}| \quad (1)$$

in the formula, each of factors, E_c , $C_{\text{HOMO},n}$, $E_{\text{HOMO},n}$,
20 $C_{\text{LUMO},n}$, and $E_{\text{LUMO},n}$ represents a value calculated by a
semiempirical molecular orbital method MOPACPM3, E_c
representing an orbital energy (eV) of a radical of the
radical-generating agent as a vulcanizing agent, $C_{\text{HOMO},n}$
representing a molecular-orbital coefficient of the
25 highest occupied molecular orbital (HOMO) of an n-th active
atom constituting a basic unit of the thermoplastic resin,
 $E_{\text{HOMO},n}$ representing an orbital energy (eV) of the HOMO,

$C_{LUMO,n}$ representing a molecular-orbital coefficient of the lowest unoccupied molecular orbital (LUMO) of the n-th active atom constituting the basic unit of the thermoplastic resin, and $E_{LUMO,n}$ representing an orbital
5 energy (eV) of the LUMO.

2. A rubber-reinforced structure which comprises at least one resin member comprising a resin composition, and at least one rubber member being directly bonded to the resin member without any adhesive, wherein the resin
10 member and the rubber member form a tire, the rubber member comprises a rubber composition vulcanized with a sulfur-containing vulcanizing agent or a radical-generating agent, and the resin member comprises at least one member selected from the group consisting of a
15 thermoplastic resin and a resin having a crosslinkable group.

3. A rubber-reinforced structure according to claim 2, wherein the rubber member comprises a styrene-diene-series rubber composition vulcanized with
20 a sulfur-containing vulcanizing agent or a rubber composition vulcanized with a radical-generating agent, and the resin member comprises a polyphenylene ether-series resin composition.

4. A rubber-reinforced structure according to any
25 one of claims 1 to 3, wherein the resin member comprises a reinforcing layer of the tire.

5. A rubber-reinforced structure according to any

one of claims 1 to 3, wherein the resin member forms an adhesive layer to at least one rubber layer or rubber member constituting the tire.

6. A rubber-reinforced structure according to any
5 one of claims 1 to 3, wherein the resin member is bonded to the rubber member through a vulcanized rubber layer vulcanized with a vulcanizing agent.

7. A rubber-reinforced structure according to any
one of claims 1 to 3, wherein the thermoplastic resin
10 comprises at least one member selected from the group consisting of a polyamide-series resin, a polyester-series resin, a poly(thio)ether-series resin, a polycarbonate-series resin, a polyimide-series resin, a polysulfone-series resin, a polyurethane-series resin, a
15 polyolefinic resin, a halogen-containing vinyl-series resin, a styrenic resin, a (meth)acrylic resin, and a thermoplastic elastomer.

8. A rubber-reinforced structure according to any
one of claims 1 to 3, wherein the thermoplastic resin
20 comprises at least one member selected from the group consisting of an aliphatic polyamide-series resin, an aromatic polyester-series resin, a polyacetal-series resin, a polyphenylene ether-series resin, a polysulfide-series resin, a polyurethane-series resin, a
25 polyolefinic resin, a polyamide-series elastomer, a polyester-series elastomer, a polyurethane-series elastomer, a polystyrenic elastomer, and a polyolefinic

elastomer.

9. A rubber-reinforced structure according to claim 2, wherein the resin having a crosslinkable group comprises at least one member selected from the group
5 consisting of a thermosetting resin, and a thermoplastic resin having an unsaturated bond.

10. A rubber-reinforced structure according to any one of claims 1 to 3, wherein the rubber vulcanizable with the radical-generating agent comprises at least one
10 member selected from the group consisting of a diene-series rubber, an olefinic rubber, an acrylic rubber, a fluorine-containing rubber, a silicone-series rubber, and a urethane-series rubber.

11. A rubber-reinforced structure according to
15 any one of claims 1 to 3, wherein the radical-generating agent comprises at least one member selected from the group consisting of an organic peroxide, an azo compound, and a sulfur-containing organic compound.

12. A rubber-reinforced structure according to
20 claim 1 or 2, wherein at least one member selected from the group consisting of the rubber member and the resin member is formed from a composition containing a vulcanization-activating agent.

13. A rubber-reinforced structure according to
25 claim 12, wherein the vulcanization-activating agent has a plurality of polymerizable groups.

14. A rubber-reinforced structure according to

claim 12, wherein the amount of the vulcanization-activating agent is 0.1 to 10 parts by weight relative to 100 parts by weight of the rubber or the resin.

15 15. A rubber-reinforced structure according to claim 12, wherein the amount of the vulcanization-activating agent is not more than 2 parts by weight relative to 100 parts by weight of the rubber.

10 16. A process for producing a rubber-reinforced structure which comprises
bringing a resin element for forming a resin member into contact with at least one rubber element, wherein the resin element is selected from the group consisting of an unmolded resin composition, a semi-molded resin member and a molded resin member, the rubber element is selected from
15 the group consisting of an unvulcanized rubber composition and a semi-vulcanized rubber member, and the resin member and the rubber element form a tire,

20 vulcanizing an unvulcanized rubber of the rubber element to bond the formed vulcanized rubber member to the resin member,

wherein the resin element and the rubber element are used in any one of the following combinations:

25 (i) a combination of a rubber element containing a radical-generating agent, and a resin element containing a thermoplastic resin having at least two active atoms on the average per molecule, wherein each of the atoms is selected from the group consisting of a hydrogen atom and

a sulfur atom and has an orbital interaction energy coefficient S represented by the formula (1) recited in claim 1 of not less than 0.006;

(ii) a combination of a rubber composition
5 containing a sulfur-containing vulcanizing agent or a radical-generating agent, and a resin composition containing at least one resin selected from a thermoplastic resin and a resin having a crosslinkable group; or

(iii) a combination of a styrene-diene-series
10 rubber composition containing a sulfur-containing vulcanizing agent or a rubber composition containing a radical-generating agent, and a resin composition containing a polyphenylene ether-series resin.

17. A process according to claim 16, wherein at
15 least one element of the resin element and the rubber element contains a vulcanization-activating agent.

18. A process according to claim 16, wherein the resin element comprises a vulcanization auxiliary comprising a compound having at least two active atoms on
20 the average per molecule, wherein each of the atoms is selected from the group consisting of a hydrogen atom and a sulfur atom and has an orbital interaction energy coefficient S represented by the formula (1) recited in claim 1 of not less than 0.006.

25 19. A process according to claim 16, wherein the resin element and the rubber element are heat-molded with a vulcanization-activating agent interposing therebetween

to bond the formed resin member to the formed rubber member.

20. A process according to claim 16, wherein the resin element and the rubber element are heat-molded with a coating layer containing a vulcanization-activating agent and a vulcanization auxiliary interposing on the contact surface of the resin element with the rubber element to bond the formed resin member to the formed rubber member, wherein the vulcanization auxiliary comprises a compound having at least two active atoms on the average per molecule, wherein each of the atoms is selected from the group consisting of a hydrogen atom and a sulfur atom and has an orbital interaction energy coefficient S represented by the formula (1) recited in claim 1 of not less than 0.006.

21. A process for producing a rubber-reinforced structure, which comprises a step for bonding a resin member to at least one rubber element, wherein the resin member is selected from the group consisting of a semi-molded resin member and a molded resin member, the rubber element is selected from the group consisting of an unvulcanized rubber composition and a semi-vulcanized rubber member, and the resin member and the rubber element form a tire, and

the bonding step comprises treating the surface of the resin member with a solvent capable of dissolving or swelling the resin member, bringing the treated surface of the resin member into contact with the rubber element, and vulcanizing an unvulcanized rubber of the rubber

component to bond the vulcanized and formed rubber member to the resin member.